Article

Identification of Nonhuman Remains Received in a Medical Examiner Setting

James T. Pokines

Office of the Chief Medical Examiner
and
Boston University School of Medicine
Boston, MA

Abstract: Forensic cases of skeletal or partially decomposed remains are frequently identified as nonhuman by forensic anthropologists or pathologists working in medical examiner or similar settings. Knowledge regarding which nonhuman species are turned in at the highest frequencies in a given region therefore will be useful for training forensic practitioners in nonhuman bone identification and lead to faster case resolution. The present research examined n = 355 cases turned over to the Office of the Chief Medical Examiner, Boston, from all jurisdictions in the Commonwealth of Massachusetts. The majority were received from November 2011 through October 2014, although some older cases were also included. The vertebrate species community in this northeastern United States region reflects the multiple environments throughout the state, including woodland, agricultural, and marine. The introduced domestic species cattle (*Bos taurus*) and pig (*Sus scrofa*) and abundant wild species white-tailed deer (*Odocoileus virginianus*) were the top three taxa identified, and in general introduced domestic species dominated the profile. Nonhuman animal remains derived from accidental excavation of archaeological or historical midden deposits were an important source of skeletal remains, as was recent food waste. Although the majority of remains turned in for examination were comparable in size to adult humans, smaller taxa also contributed a significant proportion of the overall case sample. Forensic practitioners in regions with similar species populations may encounter nonhuman taxa at broadly similar rates. Forensic education programs should include a focus on their identification, because nonhuman cases may comprise a significant portion of overall casework.

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Introduction

One of the tasks of the forensic anthropologist (or in some cases, pathologist) working in a medical examiner office is determining whether skeletal or partially decomposed remains are human or nonhuman [1–4]. Indeed, most analysis ceases as soon as remains are identified as nonhuman, and the nonhuman remains normally are discarded at that point, similar to the process where presumptive remains are determined to be non-osseous. The majority of analytical time can then be devoted to human cases and associated multiple analyses necessary, including the basic biological profile and perimortem and antemortem trauma. The detail level of analysis is also much lower for nonhuman than human remains, because often a simple, single-page form is all that is needed to document their final disposition (i.e., disposal). Additional testing may be necessary in cases where the remains are highly fragmented, and thus histological [5–7] or PCR [8] analysis may be employed to eliminate skeletal remains as nonhuman. Most cases, however, require only identification of macroscopic morphological differences in bone structure to differentiate among taxa.

Forensic anthropologists report varying amounts of nonhuman cases among their total case loads [9]. Bass and Driscoll [10] noted that for a sample of 111 cases from 1971 to 1981 in Tennessee, 20% were nonhuman, with a rate of zero to seven cases submitted per year over that span. Marks [11] later reported that the percentage of nonhuman cases in Tennessee had climbed to nearly 30% of an increasingly large case load. In a summary of overall forensic casework performed by diplomates of the American Board of Forensic Anthropology for the year 1995, Reichs [12] indicated that nonhuman cases made up approximately 18% of nonforensic cases (including historic and prehistoric burials) in their overall case loads; the percentage of overall case load reported would have been lower. Falsetti [13] compiled a sample of 999 forensic cases examined by William R. Maples at the University of Florida and noted that 11% were determined to be nonhuman remains; that study also noted a steady climb overall in the total number of forensic cases received per year. Similarly, Ubelaker [14] discussed the forensic anthropology career of T. Dale Stewart at the Smithsonian Institution in Washington, D.C., and noted that of a sample of 254 cases, 90% consisted of only human remains, 6% consisted of human and nonhuman remains, and 4% of cases consisted of only nonhuman remains. Grisbaum and Ubelaker [15] further tabulated the percentage of nonhuman cases out of 474 cases

containing substantial skeletal remains that had been presented to the Smithsonian Institution for the span 1962 to 1994, as compiled from (non-archaeological) cases that were provided by the FBI and derived from all over the United States. They found that 71.9% of cases consisted of only human remains, 13.7% consisted of human and nonhuman remains, and 14.3% of cases consisted of only nonhuman remains. Gruspier [16] tabulated approximately 400 nonhuman cases in a two-year span from 2010 to 2012 for forensic anthropological analysis in Ontario, Canada, but she did not note the percentage of cases overall that were nonhuman. These high numbers of nonhuman cases presented for forensic anthropological analysis indicate the need for expert training by all practitioners who make final determinations in these situations, because nonhuman cases may comprise a significant proportion of casework.

The identification of nonhuman remains also may occur in cases involving the illegal traffic in body parts (bones, tusks, pelts, shells, quills, feathers, etc.) of endangered wildlife species, and this information can then be forwarded to appropriate government agencies or specialists brought in for confirmation on the identification of exotic taxa. Cases of animal abuse likewise may require forensic examination of their remains for species identification or trauma and pathology analysis [17]. Identification of nonhuman remains also may be required where large fatality incidents such as house fires or explosions potentially commingled human and nonhuman (likely house pet) remains, often in highly fragmented and thermally altered states. The casework of the author also included a case of suspected (to others) cryptozoology (i.e., the determination that remains were not "Sasquatch" in origin). In addition, taphonomic analysis of nonhuman remains affords the forensic anthropologist a large sample of many of the typical taphonomic alterations that may be encountered on human skeletal remains from the same jurisdiction. These modifications include those occurring on surface remains, with their frequent alterations by decomposition staining, carnivore and rodent gnawing, and weathering; marine remains, typically displaying bleaching, rounding, abrasion, and organism growth; and buried remains, typically displaying soil staining, loss of organic content, plant root invasion, and acidic soil corrosion [9]. Many resources exist to aid the forensic practitioner regarding differences in bone morphology among human and nonhuman vertebrate species [1, 3, 18–30]. Print resources alone, however, are just one component to aid in the identification of skeletal remains as nonhuman, and analysis

should include comparison with known exemplars, especially where remains are fragmented. Planning which species are the most necessary for such a collection can be greatly aided by a knowledge of which species are most likely to need identification and a knowledge of the local faunal community.

The present study examines nonhuman cases analyzed by the Forensic Anthropologist for the Commonwealth of Massachusetts, Office of the Chief Medical Examiner (OCME MA), Boston. Massachusetts is located in the temperate zone on the North Atlantic, with mixed evergreen and deciduous forest coverage from the western mountainous region through the sandy soils of the Cape Cod and islands area on the east coast. Forest cover of all types comprises around 60% [31], and agricultural land of all types (crops, pasture, etc.) comprises more than 10% of the state [32]. The eastern environments of the state are dominated by the urban center of Boston and the developed coastal plain. Areas of coastline and islands are extensive relative to the size of the state. The population in 2013 was just under 100,000 in the rural (primarily western) and 6.6 million in the urban (primarily eastern) portions [32]. The land area of the state encompasses 7800 miles^2 (20,202 km^2). Overall population density therefore is high (839.4 people/mile^2), ranked third in the United States by the 2010 census [33]. This high population density may be a factor in the high rate of discovery of skeletal remains (see below).

Materials and Methods

A total of 355 cases are included in the present sample. The majority were received from November 2011 through October 2014, although some older cases are also included. Notifications for all cases of remains reported in all jurisdictions in the state are sent to the OCME MA in Boston. The environments sampled include evergreen, mixed, or deciduous forest; agricultural land; coastal margins; fresh and saltwater wetlands; and urban or suburban settings. Sources commonly included bones encountered on the surface by private citizens or those unearthed during construction activity or home renovation. Identification was through physical macroscopic examination, with the exception of one case employing histological examination of highly fragmented bone. This lone case displayed plexiform bone structure, indicating nonhuman origin [5]. Where unambiguously possible, identification was made through photographs; all cases with any doubt regarding identification from

photographs alone were sent to the OCME MA for analysis. Data gathered included the taxa present, fusion state of the bones, and skeletal elements. Taphonomic data were also gathered to confirm the reported origins of the remains. Identification of mammals, birds, and reptiles was to species level when possible, but in some cases, these taxa could be identified only to higher taxonomic groupings. No attempt was made to identify bony fish beyond their superclass (Osteichthyes). No amphibian remains were identified in the sample.

The environment from which the remains were derived was taken from the law enforcement reports of their finds, as confirmed by taphonomic analysis of the remains. Environments were broken into seven categories: terrestrial surface, buried, marine or shore, domestic, fresh water, salt water marsh, and unknown.

Results

Taxonomic Identification

Taxonomic identifications are presented in Table 1. Remains, usually skeletonized, from domesticated cattle (*Bos taurus*) were present in 105 cases (29.6%), followed closely by white-tailed deer (*Odocoileus virginianus*), which were present in 104 cases (29.3%). The white-tailed deer cases tended to have more soft tissue present than the domestic cattle cases. This is likely due to much of their inclusion deriving from wild deaths. Pig (*Sus scrofa*) remains were present in 93 cases (26.2%). Less common taxa included seals (Phocidae) (n = 24; 6.8%), unidentified large bird taxa (n = 22; 6.2%), chicken (*Gallus gallus*; n = 19; 5.4%), dog (*Canis familiaris*; n = 14; 3.9%), and sheep/goat (*Ovis aries/Capra hircus*; n = 15; 4.2%). Other taxa were far rarer and were identified in no more than seven cases each. These include seven cases with large birds identifiable to the subfamily Anserinae (geese and swans) and two additional cases identified within this subfamily to the (introduced) species mute swan (*Cygnus olor*). Turkey (*Meleagris gallopavo*) was identified in four cases, and one case included remains from the avian family Laridae (gulls). Other terrestrial taxa appearing in small amounts included cat (*Felis catus*), black bear (*Ursus americanus*), horse (*Equus caballus*), rat (*Rattus* sp.), woodland vole (*Microtus pinetorum*), and snake from the family Colubridae. Additional aquatic species included bony fish (unknown marine or freshwater), sea turtle (superfamily Chelonioidea), an additional case identifiable to leatherback turtle (*Dermochelys coriacea*), and oceanic dolphin (Delphinidae).

Common Name	Taxon	Number of Cases	% of (n=355) Cases
Cattle	*Bos taurus*	105	29.6
White-tailed deer	*Odocoileus virginianus*	104	29.3
Pig	*Sus scrofa*	93	26.2
True seals	Phocidae	24	6.8
Unknown large bird	Aves	22	6.2
Chicken	*Gallus gallus*	19	5.4
Sheep/goat	*Ovis aries/Capra hircus*	15	4.2
Dog	*Canis familiaris*	14	3.9
Unknown mammal	Mammalia	12	3.4
Geese and swans	Anserinae	7	2.0
Cat	*Felis catus*	6	1.7
Bony fish	Osteichthyes	5	1.4
Turkey	*Meleagris gallopavo*	4	1.1
Black bear	*Ursus americanus*	3	0.8
Sea turtle	Chelonioidea	2	0.6
Horse	*Equus caballus*	2	0.6
Mute swan	*Cygnus olor*	2	0.6
Rat	*Rattus* sp.	2	0.6
Woodland vole	*Microtus pinetorum*	1	0.3
Leatherback turtle	*Dermochelys coriacea*	1	0.3
Oceanic dolphin	Delphinidae	1	0.3
Snake	Colubridae	1	0.3
Gull	Laridae	1	0.3

Table 1

Nonhuman taxonomic identifications. Percentage indicates the frequency that taxon was identified among cases in the sample; some cases contained more than one taxon.

The majority of cases (84.8%) included only a single taxon (Table 2, Figure 1), with the remaining cases presenting the following minimum multiple identified taxa: two taxa (7.9% of cases), three taxa (5.4%), four taxa (1.1%), and five taxa (0.6%), and a single case included a minimum of six taxa (0.3%).

Min. No. of Taxa in Case	n =	%
1	301	84.8
2	28	7.9
3	19	5.4
4	4	1.1
5	2	0.6
6	1	0.3

Table 2

Minimum number of taxa present in each case.

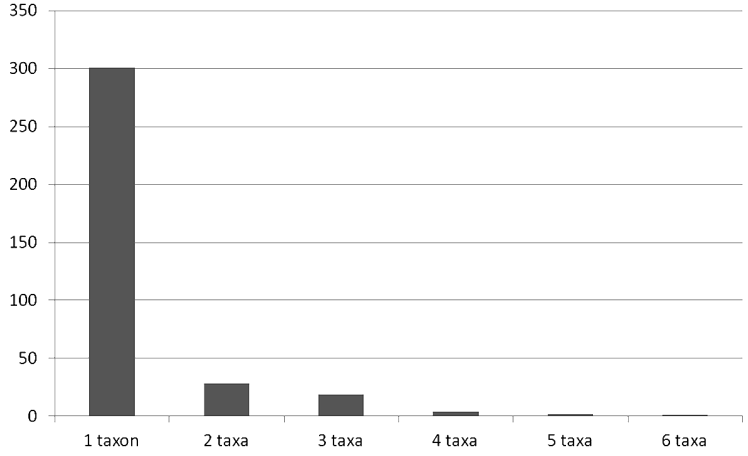

Figure 1

Number of taxa present in each case.

Developmental Age

Developmental age of the fauna is presented in Table 3 and Figure 2: 51.0% of cases consisted of only mature bones that had undergone their final stages of fusion, 23.4% consisted of only unfused or fusing bones, and another 9.3% consisted of bones in both adult and juvenile stages of development. In the remaining 16.3% of cases, the fusion stage could not be determined.

Age(s) Represented	n =	%
Adult only	181	51.0
Juvenile only	83	23.4
Adult and juvenile	33	9.3
Unknown	58	16.3

Table 3

Age groupings (adult and juvenile) represented in each case.

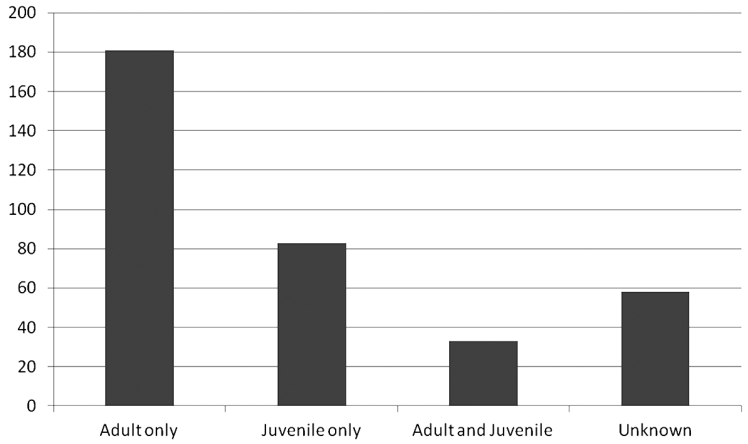

Figure 2

Age groupings (adult and juvenile) represented in each case.

Skeletal Part Representation

The majority of cases (94.1%) had no cranial elements present (Table 4, Figure 3), 1.7% of cases consisted of cranial remains only, and 4.2% of cases consisted of both cranial and postcranial remains. Eight cases in total were in the form of decomposing carcasses with some bone exposure, with the remainder consisting of either skeletonized remains or bones with some adhering soft tissue.

One particular subcategory of commercially butchered remains was a frequent occurrence: 39 separate cases were found to be a knee joint of pig (Figure 4), and only one of these cases included additional pig remains. These knees (the shank end of the ham cut) consisted minimally of the distal femur and proximal tibia, with the fibula sometimes present and the patella rarely present. This type of pig remains usually had significant soft tissue still attached and frequently had dog gnawing. Evidence of previous cooking (bleaching and translucency) was sometimes found on the bones. Machine butchery was present in each case on the shaft ends of the long bones, and in multiple cases the femur displayed regular, superficial circumferential pre-slicing cuts circling the shaft; the cuts were formed by the attached meat being pre-sliced into thin strips for later easier consumption (i.e., spiral-cut). Pre-slicing cuts were also noted in some cases of proximal pig femora articulated with portions of the pelvis, but the cuts were not found on other types of cases or involving any other species.

Skeletal Portions	n =	%
Postcranial	334	94.1
Cranial	6	1.7
Both	15	4.2

Table 4

Skeletal portions represented in each case.

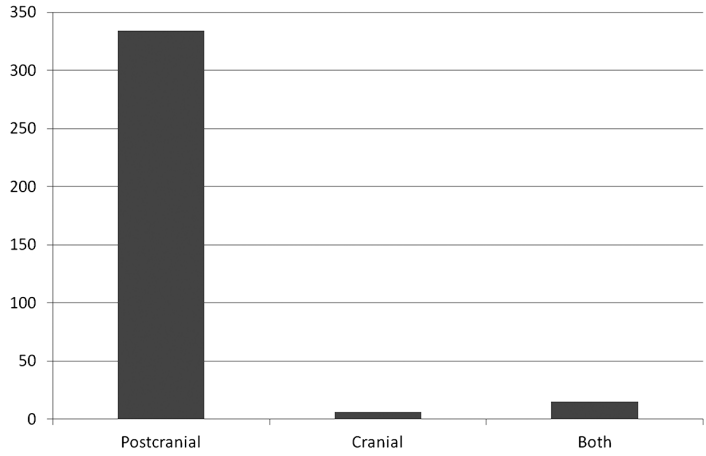

Figure 3

Skeletal portions represented in each case.

Figure 4

Typical articulated butchered pig knee joint, with only the proximal tibia and distal femur present. Both ends have been machine butchered perpendicularly across the shaft, and the distal femur displays multiple circumferential pre-slicing cuts. Much soft tissue adheres, and the exposed bone shows bleaching from cooking.

Massachusetts Environments Represented

Table 5 and Figure 5 show the environments from which these cases derived. The majority (n = 191; 53.8%) were terrestrial surface environments, which included habitats as diverse as outdoor urban settings to forest floors. Buried remains (n = 96; 27.0%) were also common and were often unearthed by accident during building projects, within basements, or outside of existing structures. Dogs were also frequently reported to have uncovered buried bone. Marine or shore cases were also common (n = 51; 14.4%); these included remains from ocean water or more commonly those that had washed ashore from the ocean. Domestic remains (n = 9; 2.5%) were rare and refer to bones discovered within the crawl spaces of buildings (i.e., within the structures themselves and not buried underneath buildings). All types of fresh water (lakes, ponds, and rivers) also were a rare source of remains (n = 4; 1.1%), and the state's extensive salt water marshes were an infrequent source of remains (n = 2; 0.6%). Unknown contexts (n = 2; 0.6%) derived from unprovenienced cases for which their environment of origin could not be clearly determined from taphonomic analysis.

Environment	n =	%
Terrestrial surface	191	53.8
Buried	96	27.0
Marine/shore	51	14.4
Domestic	9	2.5
Fresh water	4	1.1
Salt water marsh	2	0.6
Unknown	2	0.6

Table 5

Environments from which the Massachusetts cases were derived.

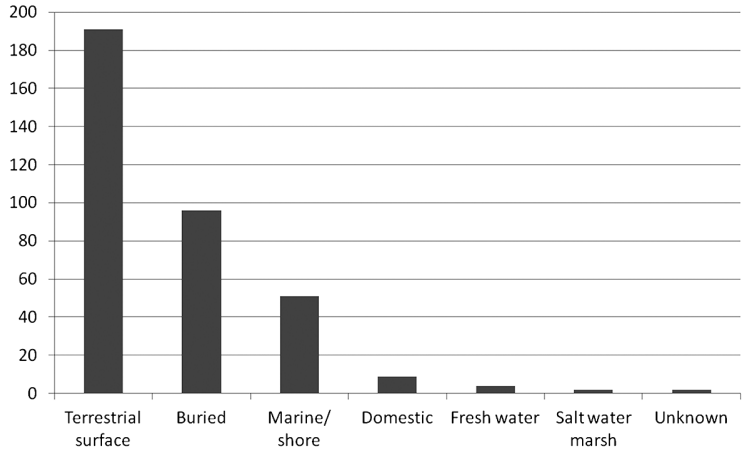

Figure 5

Environments from which the Massachusetts cases were derived.

Taphonomic Alterations

Bones from terrestrial environments were characterized by the frequent presence of multiple taphonomic alterations, including gnawing by mammalian scavengers or rodents, weathering [34], algae formation, and patches of decomposition and topsoil staining. Weathering was not advanced in any case and reached weathering stage 3 in only one case and weathering stage 2 in two cases. Mammalian gnawing was frequently consistent with domestic dog and coyote (*Canis latrans*), with some gnawing also present from smaller species consistent with members of the weasel family (Mustelidae). Rodent gnawing was often attributable to North American porcupine (*Erethizon dorsatum*) or to much smaller taxa including *Rattus* sp. Terrestrial environments also yielded many remains with soft tissue still adhering or with the bone texture still greasy. Frequently, terrestrial remains consisted of previously machine-butchered bones [35] that were leftover food waste discovered in urban areas. Fresh remains sometimes showed signs of bleaching from previous boiling or in rare cases carbonization and calcination.

Previously buried skeletal remains often displayed the taphonomic alterations of adhering sediments, plant root infiltration, uniform soil staining, acidic soil corrosion, and chalky or friable

textures lacking residual greasiness or an organic sheen. Buried remains often displayed machine butchery, because many of the bones originated as kitchen waste buried by human or dog activity.

Taphonomic characteristics typical of marine environments included saltwater bleaching, margin rounding from abrasive tumbling, adhering sand, and the adhesion of marine taxa including barnacles, mollusks, algae, and seaweed [36]. Marine remains also often included partial carcasses that had recently washed ashore, especially seals.

Skeletal remains from domestic spaces in multiple cases displayed very greasy elements combined with pervasive small rodent gnawing and a mixture of species represented. Heavy coatings of dust were also typical. It is likely that some of these remains were collected and brought back to a nest by rats for consumption of the residual grease in the bones [37], because two of these cases had rat remains mixed with the other bones.

Percentage of Forensic Anthropological Case Work

The proportions of nonhuman and human cases received for forensic anthropological analysis for calendar years 2012, 2013, and a portion of 2014 (January through the end of October) are presented in Table 6. Note that the human cases do not include trauma-only analyses where bone portions were removed from fleshed bodies for examination of potential antemortem trauma or perimortem trauma including gunshot wound or sharp force dismemberment, nor do they include radiographic comparisons or other similar consultations. In 2012, 114 nonhuman, 13 human, and 1 combined human and nonhuman cases were examined; in 2013, 98 nonhuman and 7 human cases were examined; in 2014 (partial year totals), 80 nonhuman, 9 human, and 2 combined human and nonhuman cases were examined. The proportions for 2012 were 89.1% nonhuman, 10.2% human, and 0.8% both; the proportions for 2013 were 93.3% nonhuman, 6.7% human, and 0.0% both; and for 2014 were 87.9% nonhuman, 9.9% human, and 2.2% both. Overall proportions were 90.1% nonhuman, 9.0% human, and 0.9% both. The proportion of nonhuman to human cases varied slightly by year but averaged an approximate ten to one ratio.

Cases of nonhuman remains only co-occurred with human remains in four cases (of the total sample). One of these cases was the inclusion of skeletal snake and chicken (cranial) remains in a Palo Mayombe ritual cauldron, which was also found submerged

in fresh water [38]. Another case included the skeletal remains of a woodland vole (*Microtus pinetorum*) that had been nesting inside a cranium of a set of mostly complete surface-deposited human skeletonized remains [39].

Year	Nonhuman only	%	Human only	%	Both	%	Total	%
2012	114	89.1	13	10.2	1	0.8	128	100.1*
2013	98	93.3	7	6.7	0	0.0	105	100.0
2014**	80	87.9	9	9.9	2	2.2	91	100.0
Total	292	90.1	29	9.0	3	0.9	324	100.0

*Rounding error.

**Partial year totals only.

Table 6

Case types and percentages by year, 2012–2014.

Discussion

Comparison with Other Studies

Bass [1] reported the taxonomic identifications for a large sample of nonhuman remains deriving from forensic cases in Tennessee. A number of similarities with the present sample were apparent. He, too, found that the majority of cases were dominated by a few common species, including white-tailed deer, pig, and cattle, but in his sample, dogs were the second-most numerous taxon identified. Taxa in lesser amounts also included other introduced domesticates (chicken, horse, sheep, goat, cat, and donkey), an introduced commensal species (rat), and turkey (possibly wild or domesticated). Wild taxa included black bear but also rabbit (*Sylvilagus floridanus*), opossum (*Didelphis marsupialis*), woodchuck (*Marmota monax*), and raccoon (*Procyon lotor*), the latter four of which are common in Massachusetts but were not identified in the present sample. Bass [1] also noted small amounts of wild bird, bony fish, and reptile species. Overall, the resulting profile in Tennessee was very similar to the present study and shows a similar dominance by species whose remains in many cases may have originated as domestic food refuse. The Tennessee sample, of course, lacked marine remains, given that state's landlocked status.

There is a large difference between the present study and most published research regarding the overall percentages of forensic anthropological casework that was identified as nonhu-

man. The present study found that over 90% of the forensic case work regarding recovered or turned-in remains (therefore not including cases analyzed for perimortem and antemortem trauma only) was nonhuman, whereas the other studies previously discussed noted much lower percentages, generally in the range of 10 to 30%, with some indications of an increase over time [10–15]. Some of this difference in case load (i.e., the relative abundance of nonhuman cases presented here) may be due in large part to the success of earlier practitioners in their efforts to educate the public and law enforcement on the importance and functions of forensic anthropological analysis [11], as marked by continued growth in the membership in the American Board of Forensic Anthropology (www.theabfa.org). Overall reportage of remains of all kinds may have increased, and most reported remains are of nonhuman species. The recent reporting by Gruspier [16] that large amounts of nonhuman cases were present among her case load in Ontario, Canada, supports the explanation of a temporal trend toward greater overall reportage and hence a higher percentage of nonhuman cases turned into medical examiner offices.

Selection Biases

Clearly, only a highly filtered subset of the total amount of exposed skeletal and partially decomposed remains encountered in Massachusetts are ever reported to law enforcement, although once reported, the standard procedure is to forward the case information to the OCME MA for analysis and disposition. The factors compelling an individual to decide that the encountered remains are potentially human are unknown and may be amenable to future research. Factors that may favor reporting the remains to law enforcement include a general overlap in size with adult human remains, although many of the remains examined in the present study were so small as to be only a potential match for human infant or neonate remains. Obscuring, decomposing soft tissue may also be a factor, in that decaying masses of soft tissue can look largely alike among species except where clothing or animal fur are visible. Context also may be an important factor, in that buried remains may be more likely assumed to be human in origin. The "CSI Effect" [40–42], which has generated a greater overall interest by the public in forensic cases, may have also increased the frequency of the reporting of remains to law enforcement and hence increased the proportions of nonhuman remains examined [1, 11]. The author has also noted anecdotally that missing and presumed dead individuals

in an area being reported on local news may cause an increase in private citizens contacting law enforcement regarding the finding of any remains in that area.

Relative species abundance is a likely factor in reportage rates. White-tailed deer are abundant in Massachusetts as they are through large portions of North and South America, and their behavioral patterns bring them into frequent contact with humans, even in urbanized areas. Black bear, in contrast, is currently rare in Massachusetts, but its population is on the rise; as a large carnivore, its population normally would be a small percentage of the total wild animal population (relative to herbivores). Despite the greater superficial resemblance between the foot elements of black bears and humans [1, 2] than between white-tailed deer and humans, far fewer black bear remains are likely to be reported to law enforcement because of their lower population levels in the area. The large component of domesticated species found in the present research might be reduced relative to wild species in portions of the United States where more wild animals exist or live in closer proximity to humans. Similarly, regional differences in species will bring about variations among major jurisdictions, as will the urban to rural proportions of those jurisdictions. Jurisdictions with sea coasts are also likely to have a significant marine component as was found in the present research, while inland jurisdictions may lack marine remains entirely [1].

Other factors may simply make a given set of remains more visible and therefore more likely to be discovered, thus increasing their representation in the present sample. Weathered skeletal remains become bleached pale through ultraviolet exposure [34, 43], and this bleaching may make the bone much more visible when lying on a ground surface and less camouflaged by natural staining patterns from organism decomposition, topsoil, algae growth, and leached plant tannins [44]. Increased weathering leads to the breakdown of bones, which may be in part why no bones higher than weathering stage 3 were submitted for analysis. Bones at higher weathering stages also have lain on the surface longer, sometimes for several years [34], and bones that have been exposed on the surface for that long tend to become slowly buried by the accumulation of decomposing leaf litter. Thus, bones at higher weathering stages may be less visible on average. It is also possible that skeletal elements that are encountered in higher weathering stages may be recognized by the general public as having been exposed for multiple years or decades and therefore assumed to be less likely

of forensic interest. Bones from marine environments also often become highly bleached [36], which may increase their visibility along shorelines and increase the likelihood of their being found among other beach detritus along the high tide mark.

The low levels of cranial relative to postcranial nonhuman remains turned in to a medical examiner's office may be due to multiple factors. For domesticated species derived from commercial butchery food waste, cranial parts are far less likely to be available for purchase in typical modern supermarkets because of their generally lesser desirability. This availability may increase in areas where traditional food markets include cranial portions for sale. In addition, animal skulls (at least those with teeth present) may be much more recognizable to the average person as being nonhuman in origin: a set of remains with the skull present may never be reported to law enforcement at all. Conversely, the recognizability of animal skulls also may lead to their collection by passers-by as objects of decoration. In these scenarios, a set of remains that may once have been clearly nonhuman may now be less so after its cranial portions have been removed. The postcranial remains may then be discovered by another person who, lacking the clearly nonhuman cranial portions, is therefore less certain of their origin, and contacts law enforcement. Nonhuman animal cranial remains are also much more likely to be depicted in popular art and graphic design than their postcranial remains, making their recognition by the general public potentially easier. An exception to the pattern of a lack of cranial remains occurs among dog and cat remains, which were frequently discovered with cranial remains present. This pattern is the logical result of pet burials or other disposal, and individuals may be reluctant to collect crania from such remains, especially if they are still decomposing.

Different levels of osteological knowledge cannot be discounted as a factor in reportage. Some individuals with a rural agricultural upbringing may be much more highly informed about the appearance of nonhuman skeletal remains and much less likely to mistake these for human and report them. Similarly, some hunters of white-tailed deer may be more familiar with that species' basic osteology and may recognize encountered remains in rural areas or simply expect to find them in wilderness areas. Urban dwellers may have a relative lack of nonhuman osteological knowledge. Because much of the nonhuman bone reported from urban areas is domestic food waste (deriving from recent trash or buried historical middens), butchery may have rendered these skeletal elements even less recognizable to the average

person. Notably, in three of the cases where pig knee joints were turned in, the remains were found by persons with self-reported medical backgrounds (one practicing medical doctor of unknown specialty, one orthopedic surgeon, and one medical student), so this particular area of the pig skeleton may be particularly prone to be mistaken for human even by those with training in human anatomy.

Mixed assemblages of taxa are also likely to include skeletal remains of smaller species that, if encountered on their own, would not be mistaken by an individual for potentially human. In particular, one case in this sample that included rat remains was recovered during home renovations in an interior building space; these remains likely were accumulated by this or other rats, with this individual rat dying in its nest among the accumulated remains. The person discovering the bone accumulation may have been able to sort out these small bones as likely nonhuman if prompted but wisely did not tamper with potential evidence of a homicide until it was examined by professionals. Similarly, historical midden deposits often include a mix of taxa, and the remains of smaller species including birds may tag along with their larger mammalian counterparts. If the bird remains, for example, had been encountered on their own, the private citizens encountering them may only have contacted law enforcement if they suspected that the skeletal remains were those of an infant.

Previous knowledge of archaeological or cemetery sites in the area also may prompt an individual to err on the side of caution and report remains, even when the bones otherwise seem less likely to be human in origin; individuals may associate all buried bones with a cemetery origin. Homeowners in particular who are excavating within their own basement or on their lawn are a frequent source of osseous remains, and their knowledge of the long history of European and pre-Contact sites in the area may be a factor in their decision making. Construction crews regularly report the finding of bones within Massachusetts, which prove on occasion to be human.

A surprising finding was the number of terrestrial mammal species deriving from marine contexts. Although the remains of domesticated species were likely introduced as human food waste left at the shore or thrown into the ocean, wild species with no signs of machine butchery were often encountered, including white-tailed deer. These remains may have been introduced via the river system from animals that died upstream.

Conclusion

A large component of the taxa received in a medical examiner's office or similar setting will vary regionally. For example, areas in the United States lacking coastline or with substantially different climate and vegetation than southern New England will yield different assemblages. Many of the fauna in this study, however, have a cosmopolitan distribution or are domesticated species that are common throughout large portions of the United States, Canada, and other parts of the world. The most commonly represented taxa identified in the present sample were derived from domestic food refuse. Cases involving nonhuman remains can often be related to food preparation, especially where traces of commercial butchery are present [35].

Notably, the bulk of remains analyzed here are from species introduced to North America: cattle, pig, chicken, sheep and goat, cats, horse, mute swan, and rats. Thus, researchers throughout the region are likely to encounter them in addition to native species. Skeletal materials for comparative collections of these introduced species are relatively easy and inexpensive to obtain, some likely at no cost provided that the forensic practitioners can macerate and otherwise prepare the skeletons on their own; the equipment and materials for maceration are a necessary component of skeletal analysis and should be on hand in medical examiner offices. White-tailed deer skeletons similarly are easily obtained throughout most of North America, because this species is often culled to reduce overpopulation and is hunted extensively. It is also frequently dumped by wildlife agencies after being found as roadkill. Turkey, although native, has been domesticated and is also easily obtained. The other taxa analyzed here are in some cases protected, as in seals and sea turtles; when encountered in the wild, their remains are also of interest to wildlife agencies, which likely have specialists available who can identify them. In addition, black bears are of particular interest to forensic anthropologists and pathologists, because their fore and hind paw skeletal elements are often mistaken for human [1, 3]. Particular care in their examination therefore is needed, and their skeletal remains (if legally obtainable) may prove particularly valuable in specific cases.

Other taxa are easily discriminated from human (i.e., most birds, rodents, and small carnivores), so their identification to species level through the use of extensive faunal collections of a zoological museum is not necessary in most forensic cases. Thus, a relatively small faunal skeletal collection may make identification confirmation much easier without taking up an inordinate amount of work or storage space.

The overall patterns encountered here may be relevant for those working in medical examiner offices in determining which nonhuman taxa are likely to be introduced into casework and hence which taxa may require additional training or comparative collections to recognize, especially when fragmented remains are encountered. The author also recommends that the nonhuman taxa examined here that are common throughout North America should be emphasized in forensic anthropological curricula during comparative osteology instruction. In some cases, the identification of remains of endangered or locally uncommon species will be of interest to wildlife agencies responsible for that local area, and these agencies in turn likely include experts on the morphology of those taxa. A greater familiarity with the morphology of common nonhuman species also will allow for a higher percentage of cases to be identified as nonhuman from photographic evidence alone, thus eliminating transportation time for law enforcement of the actual bones and reducing the amount of time to keep officers on-scene to secure it while the identification of nonhuman remains proceeds. This quicker case resolution time also benefits any private or commercial interests (including construction activities) delayed in response to the finds of unidentified osseous remains. Greater familiarity with locally common nonhuman species will also reduce the number of site visits needed by forensic personnel to scenes, thus preserving their time for more complicated cases of human remains. Overall, the potential for a greater percentage of cases to be resolved through quick and efficient analysis, given the temporal trend for an overall increase in nonhuman cases, will be a cost- and time-saving measure for medical examiner offices and other forensic practitioners.

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For further information, please contact:

James T. Pokines
Office of the Chief Medical Examiner
720 Albany Street
Boston, MA 02118
and
Boston University School of Medicine
72 E. Concord Street, L1004
Boston, MA 02118
jamespokines@gmail.com

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